MAINTENANCE-RELATED ACCIDENTS: A COMPARISON OF AMATEUR-BUILT AIRCRAFT TO ALL OTHER GENERAL AVIATION

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In a previous study, Goldman, Fiedler, and King (2002) found that a little over 7% of the 1983-1999 National Transportation Safety Board general aviation (GA) accident investigation reports listed at least one maintenance-related error as the primary cause or factor. Amateur-built aircraft accounted for an average of 14% of these same general aviation maintenance-related accidents, even though amateur-built aircraft account for less than 3% of the GA hours flown. Using the 1983-2001 National Transportation Safety Board GA accident investigation reports, this study compares maintenance-related accidents for amateur-built and all other GA aircraft by type of maintenance procedure, airframe hours, phase of operation, and time since last inspection. For this 18-year sample of maintenance-related accidents, 413 involved amateur-built aircraft, and 3,262 involved all other types of GA aircraft. General aviation flight hours continue to increase: Amateur-built aircraft flight hours, alone, increased from under 300,000 hours in 1993 to about 900,000 in 2000.

INTRODUCTION

Although maintenance-related general aviation (GA) accidents and incidents remained steady over the past decade, there has been little research on the causes of these mishaps. In a previous study, Goldman, Fiedler, and King (2002) found that a little over 7% of the 1983-1999 National Transportation Safety Board GA investigation reports listed at least one maintenance-related error as the primary cause or factor. They also found that improper installation of aircraft parts was the most frequently cited maintenance activity associated with GA maintenance-related accidents.

Reducing maintenance and pilot errors is crucial to general aviation safety, and amateur-built (A-B) aircraft are no exception to this assumption. A-B aircraft, by definition are homebuilt, and design modifications, construction, and maintenance procedures are often carried out by one individual, who may or may not have a background in aircraft construction or maintenance. The same person who built the aircraft often flies it. Again, this person may have had little flying experience with the specific homebuilt aircraft. In the last decade, there has been a significant increase in the number of homebuilt aircraft and the number of hours flown. The Aviation Policy and Plans General Aviation and Air Taxi Activity Survey of 2000 reported that between 1993 and 2000, active A-B aircraft had risen from a little under 6,000 to over 16,000 aircraft. The same survey also reported that from 1993 to 2000, hours flown went from under 300,000 to about 900,000 hours. However, the accident rate of homebuilt compared to general aviation far surpasses the proportion of homebuilt aircraft in the general aviation community. The 1997 NTSB Annual Review of Aircraft Accident Data for U.S. GA reported that A-B aircraft accounted for 3% of the aircraft hours flown in GA flying, but made up 10% of the accidents. The same review also reported that A-B aircraft involved in accidents were destroyed 50% more often than were manufactured aircraft and the pilots were killed twice as often. In a preliminary study, Civil Aerospace Medical Institute (CAMI) researchers found that the rate of maintenance-related accidents for A-B aircraft were similar to that of rotorcraft, a type of aircraft well known for its high maintenance requirements. From 1988-1997, CAMI found there were 59 fatalities and 120 injuries in 211 maintenance-related homebuilt accidents.

Using the 1983-2001 National Transportation Safety Board GA accident investigation reports, this study compares

maintenance-related accidents for A-B and all other GA aircraft by type of maintenance procedure, airframe hours, phase of operation, and time since last inspection. For this 18-year sample of maintenance-related accidents, 413 involved A-B aircraft, and 3,262 involved all other types of GA aircraft. Maintenance procedures and maintenance personnel are defined by the codes used by the National Transportation Safety Board. All analyses include overall accident frequencies, fatalities, and injuries.

Analyses were completed to provide a human factors taxonomy of maintenance-related accident causal factors for A-B aircraft. Subsequently, this taxonomy was used to analyze the data in more detail to determine the frequency of fatalities and injuries by causal factors. The incidence of causal factors for A-B aircraft accidents was then compared with the incidence of causal factors for all other GA M-R accidents. All analyses completed for A-B aircraft (fatalities, injuries, airframe time, phase of operation, and time since last inspection) were also completed for all other maintenance-related GA accidents. This research will provide policy makers with information that can be used to guide GA maintenance-related accident prevention and develop advisory circulars.

METHOD

GA Accident Data

Final reports for all maintenance-related accident investigations between 1983 and 2001 involving GA aircraft were obtained from the National Transportation Safety Board (NTSB). As defined by the NTSB (2001), GA aircraft include "all civil flying except revenue air carrier" (including all Part 121 and all Part 135 operations). The current sample of accident reports was obtained by querying the NTSB database for accidents that included either a maintenance subject code as a cause or factor in the accident. An accident is defined as "an occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage" (NTSB, 2001). This study included only NTSB accident reports; incidents were excluded.

Two databases were developed of all M-R aircraft accidents, one for A-B, and one for all other GA. Analyses were completed on both databases to provide a human factors taxonomy of maintenance-related causal factors. Subsequently, the taxonomies were analyzed in more detail to determine the frequencies of fatalities and injuries by causal factors. Other factors studied in relation to fatalities and injuries were airframe time, phase of operation, and time since last inspection. The taxonomy of M-R causal factors for A-B aircraft was then compared to causal factors for all other GA maintenance-related accidents.

RESULTS

Total Accidents and Fatalities

From 1983 to 2001, the total number of A-B aircraft accidents was 3,572, with 1,082 fatalities (or 30%). The total number of all other GA aircraft accidents was 34,482, with 6,582 fatalities (or 19%).

Maintenance–Related Accidents and Fatalities Only

Of the 3,572 A-B accidents, 395 or 11% were M-R accidents. Of the 34,482 all other GA accidents, 2,327 or 7% were M-R accidents. There were 151 fatalities in the 395 M-R accidents for A-B, or 14% of the 1,082 fatalities for A-B aircraft. There were 810 fatalities in the 2,327 M-R accidents for all other GA aircraft, or 12% of the 6,582 fatalities.

Installation of aircraft parts was identified as the leading cause for M-R accidents in A-B, responsible for 127 or 32% of the M-R accidents in A-B. Installation was also identified as the leading cause for M-R accidents for all other GA, responsible for 397 or 17% of the M-R accidents in all other GA.

For those 104 A-B investigations that listed M-R as a causal factor and also reported airframe

time, there were 19 fatalities (18%) in the first hour of flight. For those 682 all other GA investigations that listed M-R as a causal factor and also reported airframe time, there were 20 fatalities (3%) in the first hour of flight. Thus, when maintenance is a causal factor, A-B accidents are approximately six times more likely to result in a fatal outcome in comparison with accidents in all other GA. For A-B aircraft, 33% of fatalities and 23% of M-R injuries occur during the first 10 hours of airframe time. For all other GA accidents, M-R fatalities and injuries are widely dispersed over airframe time.

Those investigations in which M-R was a causal factor and the airframe time was reported, there was only 1 more fatality in the sample of all other GA accidents than its equivalent sample in A-B. This small difference occurred despite the fact that there were over 6 times as many accidents in this restricted sample of all other GA aircraft during the first hour of flight.

For A-B aircraft, 59% of fatalities and 64% of M-R injuries occurred during the first 15 hours after last inspection. For all other GA aircraft, the number of M-R fatalities and injuries increased the first few hours after inspection, but then leveled out over time.

DISCUSSION

General aviation flight hours continue to increase: A-B aircraft flight hours, alone, increased from under 300,000 hours in 1993 to about 900,000 in 2000. The new sport pilot regulations (NPRM FAA Docket –20001-11133 Notice No 02-03) are less stringent than private or recreational pilot regulations, and therefore, are likely to stimulate an additional increase in GA flight hours. For instance, sport pilot regulations do not require a FAA medical certificate, only a U.S. issued driver's license is required. Also, the sport pilot certification only requires a minimum of 20 hours flight training, whereas recreational pilot requires 30 hours and private pilot requires 40 hours. If an increase of GA flight hours occurs, a corresponding increase in maintenance related accidents would also be expected. Identifying the most frequently occurring maintenance errors can be helpful information for creating future interventions. Subsequent research could determine the efficiency of the interventions in reducing the prevalence of accidents and fatalities.

Little research has been completed that investigates the causal factors of A-B accidents, and the research that has been done is several years old. To reduce the likelihood of future A-B accidents, the FAA, industry partners, and the GA community need information on causal factors of A-B accidents. Common accident causes identified by this research can be used by industry in the creation of their aircraft construction manuals. This information may also be sent out directly to the homebuilt owners, as well as presented at conferences and workshops geared toward homebuilt owners (e.g., E.A.A.'s AirAdventure). A further application of this research would be the creation of an interactive computer program, such as a maintenance teaching tool, of the most error-prone procedures. Ideally, this program would allow the homebuilt owner to actually view 3-D representations of common maintenance mistakes (e.g., reversal of a part in the installation process) and also show the correct way to accomplish the procedure.

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